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## Chapter 5

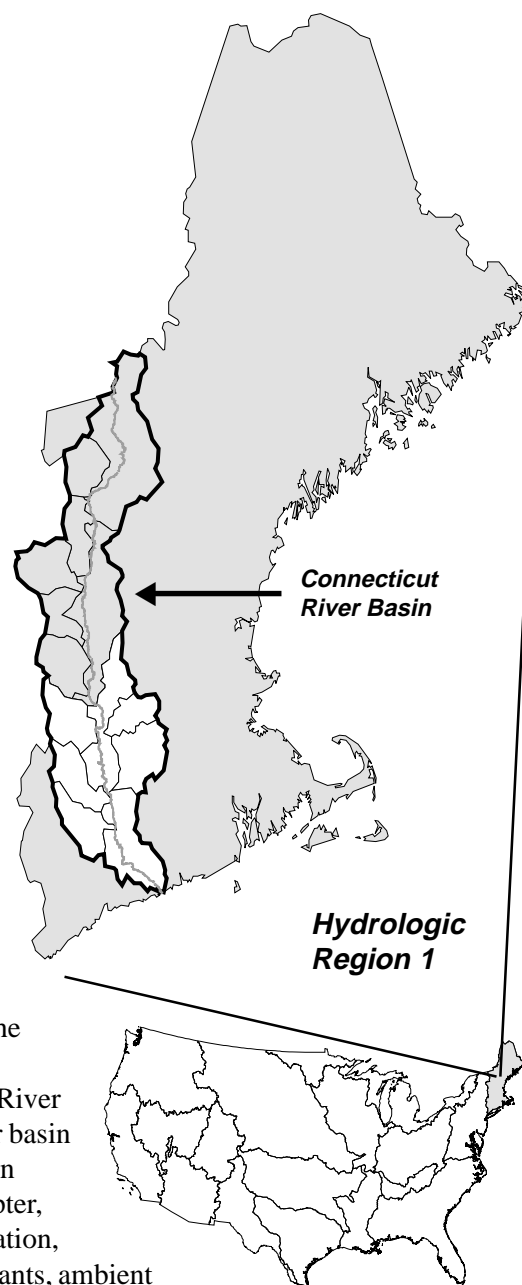
# Connecticut River Case Study

**T**he New England Basin (Hydrologic Region 1), covering a drainage area of 64,071 square miles from Maine to southwestern Connecticut, includes some of the major rivers in the continental United States. The Connecticut River, the largest river in New England, originates from a series of small lakes just south of the Canadian border and flows 400 miles south over a drainage area of 11,250 square miles through Vermont, New Hampshire, Massachusetts, and Connecticut to Long Island Sound (Figure 5-1). An estimated 1.1 million people lived in the Lower Connecticut River basin in 1996. Densely populated urban centers border the river from Springfield, Massachusetts, downstream to Middletown, Connecticut. The major urban centers along the river are Holyoke-Chicopee-Springfield, Massachusetts, and Hartford, Connecticut. A diverse mix of manufacturing, trade, finance, agriculture, recreation, and tourism forms the economic base of the basin.

Figure 5-2 highlights the location of the Lower Connecticut River case study watersheds (catalog units) identified in this major river basin as a major urban-industrial area affected by severe water pollution problems during the 1950s and 1960s (see Table 4-2). In this chapter, information is presented to characterize long-term trends in population, municipal wastewater infrastructure and effluent loading of pollutants, ambient water quality, environmental resources, and uses of the Lower Connecticut River. Data sources include USEPA's national water quality database (STORET), published technical literature, and unpublished technical reports ("grey" literature) obtained from local agency sources.

## Background

Although the Connecticut River has been characterized as one of the Nation's most scenic rivers, the river was so grossly polluted in the 1960s that it was classified as suitable only for transportation of sewage and industrial wastes. The deplorable condition of the river discouraged development along the waterfront and adjacent shorelands over long reaches of the lower river. In recent

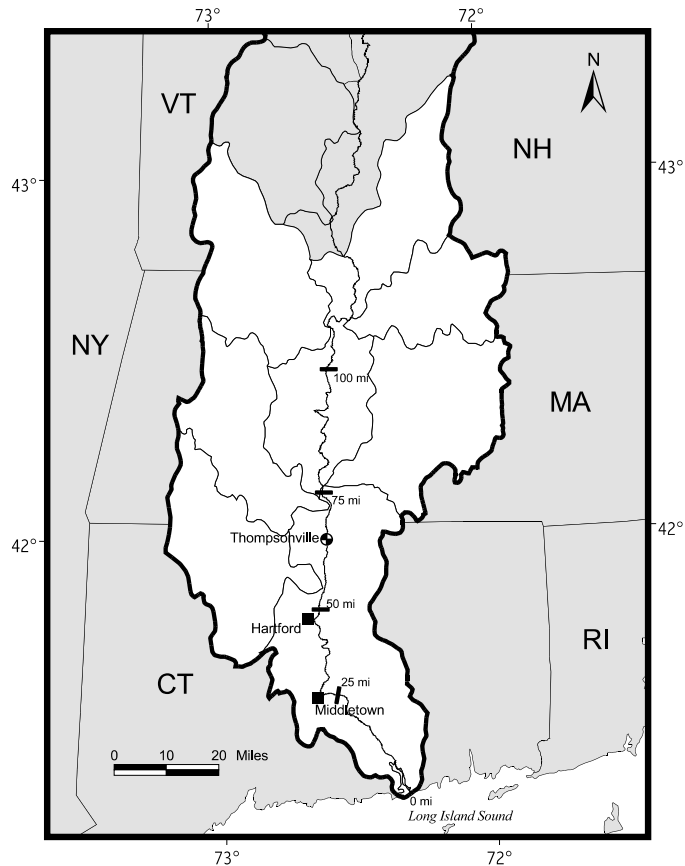


**Figure 5-1**

Hydrologic Region 1 and the Connecticut River Basin.

**Figure 5-2**

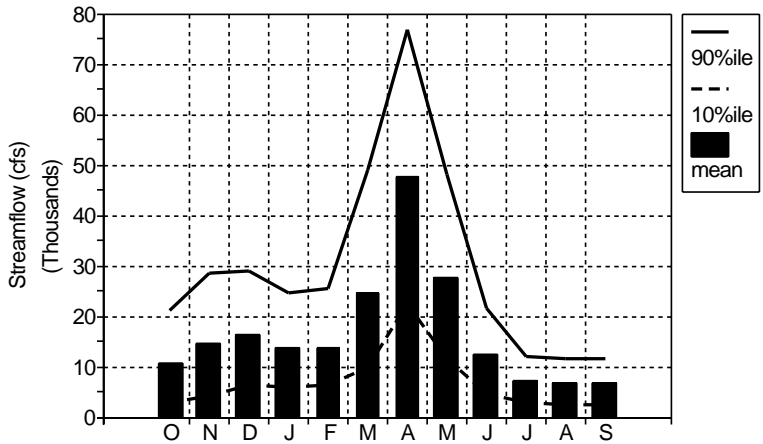
Location map for Lower Connecticut River Basin. (River miles shown are distances from Long Island Sound.)



years, amazing improvements in the river's water quality have resulted in the Lower Connecticut River's becoming a popular place for boating and recreation. Perhaps most telling of all, the shorelines of the Connecticut River are now under the new threat of suburban development. The historic turnaround in the quality of the river can be correlated with the enactment of the 1972 CWA, which resulted in the construction and upgrading of wastewater treatment plants along the length of the river, including three major treatment plants serving the Hartford area.

## Physical Setting and Hydrology

The Connecticut River forms the border between Vermont and New Hampshire and bisects west-central Massachusetts and central Connecticut. The topography of the Connecticut River's 11,250-square-mile watershed varies from the rugged terrain of the White Mountains in New Hampshire and the rounded hills and mountains in Vermont and Massachusetts to the lowlands of the floodplains along the river's banks in Massachusetts and Connecticut. Rising in the semimountainous area of northern New Hampshire, the Connecticut River drops more than half of its 2,650 feet in elevation in the first 30 miles of its course. The river is tidally influenced from Hartford to Long Island Sound (Figure 5-2).

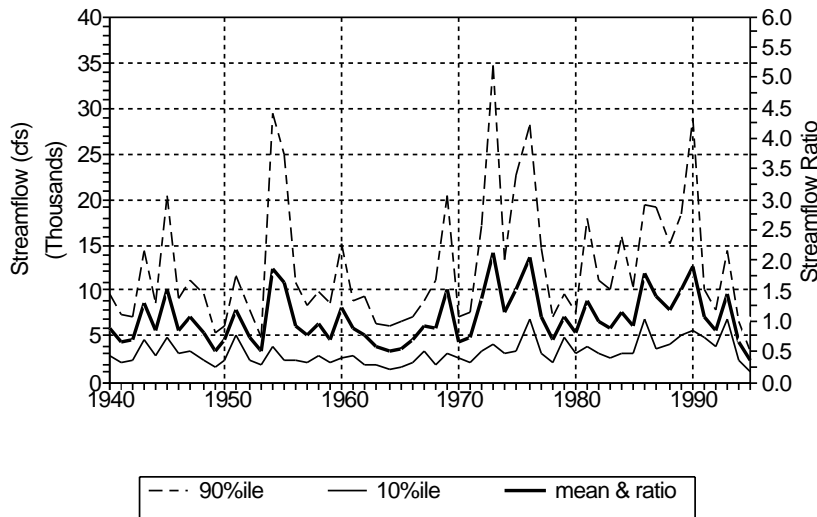


**Figure 5-3**

Monthly trends of mean, 10th, and 90th percentile streamflow for the Connecticut River at Thompsonville, CT (USGS Gage 01184000), 1951-1980.

Source: USGS, 1999.

Long-term trends in summer streamflow from the USGS gage at Thompsonville, Connecticut, shown in Figure 5-3, illustrate the interannual variability of discharge during the critical summer months. Seasonal flow conditions reflect the long, cold winters and the relatively short summers characteristic of New England. High flows are generally experienced in the spring (March-May), corresponding to large snowmelt events (Figure 5-4). Low flows occur during the summer months. In the past, flow regulation for hydropower production at Holyoke Dam (Massachusetts) periodically reduced flows in the Connecticut River to a minimum of near zero, but minimum release requirements have been established to maintain the summer low flow at a higher level. Currently the flow is regulated by a number of headwater lakes and reservoirs, as well as power plants, with a combined usable capacity of 107 billion cubic feet (USGS, 1989) at Thompsonville, Connecticut. The 7-day, 10-year low flow (7Q10) discharge at Thompsonville is 2,200 cubic feet per second (cfs). The minimum recorded daily discharge was 519 cfs on September 30, 1984, below the Holyoke Dam and 968 cfs on October 30, 1963, at Thompsonville, Connecticut (USGS, 1989).



**Figure 5-4**

Long-term trends in mean, 10th, and 90th percentile streamflow in summer (July-September) for the Connecticut River at Thompsonville, CT (USGS Gage 01184000).

Source: USGS, 1999.

## Population, Water, and Land Use Trends

The population density in the Connecticut River Basin generally increases from the north to the south. Approximately 85 percent of the river basin's residents live in Massachusetts and Connecticut. Approximately 1.1 million people live in Connecticut municipalities adjacent to the river; the largest city, Hartford, had a 1990 estimated population of 139,739 (CSDC, 1991).

The Connecticut River case study area includes a number of counties identified by the Office of Management and Budget (OMB, 1999) as Metropolitan Statistical Areas (MSAs) or Primary Metropolitan Statistical Areas (PMSAs). The Hartford, Connecticut, MSA and three Connecticut counties, Fairfield, Middlesex, and Tolland, are included in this case study. Figure 5-5 presents long-term population trends (1940-1996) for the three counties. From 1940 to 1996, the population in the Connecticut River case study area about doubled (Forstall, 1995; USDOC, 1998).

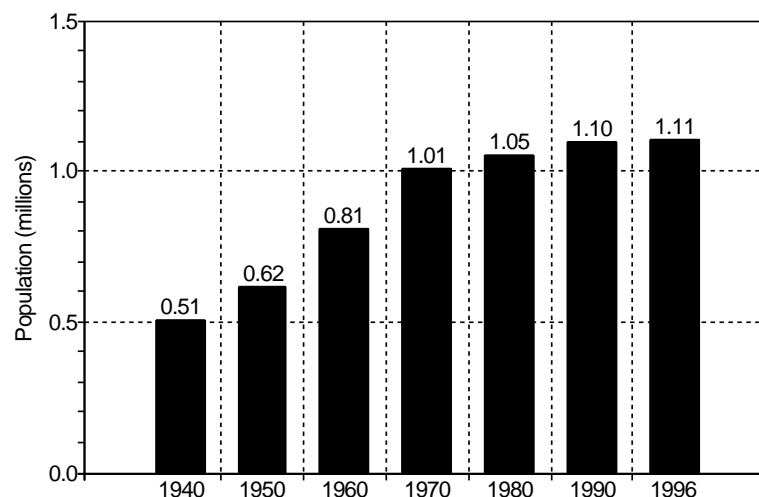
The first European settlements in the Connecticut River Basin were centered around Hartford in the 1630s. During the initial 100 years of development, the water and lands of the Connecticut River Valley provided a transportation route to the interior, as well as food and vast quantities of timber for shelter and fuel. Timber exploitation from 1700 to 1850 removed about three-fourths of the basin's forest cover. Following the timber-cutting era, cleared land was used for raising sheep and goats. The farm economy dwindled by the 1850s, and the land began to revert back to its forested condition.

The upper basin in New Hampshire and Vermont has retained a more rural character, although suburbanization is replacing traditional farm areas in some locations as the small northern towns expand. The 52-mile-long tidal section of the river in Connecticut between Long Island Sound and Hartford has traditionally supported shipbuilding and has been used as a major route for waterborne commerce, mostly petroleum products. Land use in this lower basin includes large-scale industrial and commercial development in Hartford. In the past, major

**Figure 5-5**

Long-term trends in population in the Lower Connecticut River Basin.

Sources: Forstall, 1995; USDOC, 1998.



industries in the Hartford area included woolen mills, paper mills, and machine tool factories. In recent decades, the economy of the lower basin has shifted from manufacturing toward a service economy. Hartford has been deemed “the insurance capital of the world.” Beginning with the Hartford Fire Insurance Company in 1794, insurance has become a multibillion-dollar industry.

The Connecticut River is not currently used as a public water supply in the state of Connecticut. Most of the Connecticut River water used by agriculture in the Connecticut River Valley is used to irrigate tobacco, vegetable crops, fruits, and nursery stock. In 1980 approximately 11,500 acres of the 33,922 acres of harvested cropland in Hartford County were irrigated with water from the Connecticut River or Farmington River (a major tributary just north of Hartford) (USACE, 1981).

## Historical Water Quality Issues

Water quality problems in the Hartford area of the Connecticut River date back to the late 1800s. In July 1914, the level of DO in the Connecticut River near Hartford was 2 to 3 mg/L lower than levels during the late 1980s (7.4 to 7.9 mg/L in 1988) (CTDEP, 1982, 1988). Early in the river’s history, the construction of dams for hydropower had significantly exacerbated water quality problems due to stagnation and the creation of faunal barriers. By 1872, Atlantic salmon had been completely exterminated from the river system because of poor water quality as well as the construction of physical barriers that prohibited the migration of anadromous fish (Center for Environment and Man, 1975).

In 1955, the New England Interstate Water Pollution Control Commission classified the Connecticut River from Holyoke Dam in Massachusetts to Middletown, Connecticut, as a Class D waterway suitable for “transportation of sewage and industrial wastes without nuisance and for power, navigation, and certain industrial uses” (Kittrell, 1963). Severe water pollution problems in this reach of the Connecticut River have resulted from two sources, industrial effluent and municipal sewage disposal. One of the major industries responsible for degradation of water quality has been paper mills. Before the late 1970s, paper mills in the Massachusetts segment of the river discharged effluent with high concentrations of BOD<sub>5</sub> and suspended solids into the river (Center for Environment and Man, 1975). Downstream of the paper mills in Holyoke, Massachusetts, it was reported that the river flowed different colors depending on the dye lot used at the paper mill that day.

In 1963 it was reported that in the stretch of river from central Massachusetts to south of Hartford, Connecticut, 9 of the 22 jurisdictions responsible for discharge of sewage provided no wastewater treatment. Twelve of the 22 provided only primary treatment, and 1 provided secondary treatment (Kittrell, 1963). Large discharges of municipal and industrial wastes caused a steady depletion of DO downstream of the Holyoke Dam in Massachusetts. Minimum DO levels reached nearly zero during a low flow survey in 1966, and DO levels of less than 2 mg/L were recorded in 1971. Connecticut River data collected in the summer of 1971 documented other forms of pollution with a minimum density of coliform bacteria of 75,000 colonies/100 mL and a maximum of over 1 million colonies/100 mL (Center for Environment and Man, 1975).

## **Legislative and Regulatory History**

On the basis of reports indicating that pollution in this reach of the Connecticut River was endangering the health and welfare of persons in Connecticut, the Secretary of Health, Education and Welfare convened a conference under Section 8 of the Federal Water Pollution Control Act (33 U.S.C. 466g et seq.) in 1963 to investigate the pollution of the Connecticut River in Massachusetts and Connecticut. This conference documented the appalling water quality of the Connecticut River and initiated strategies to begin to clean up the river (Kittrell, 1963). By the early 1960s, the steadily increasing public concern regarding water pollution issues resulted in organized planning for implementation of primary and secondary wastewater treatment in several municipalities including Hartford, Connecticut.

Since 1963 USEPA's Construction Grants Program has been responsible for elimination of vast amounts of untreated or partially treated wastewater entering the Connecticut River. The process of reducing the loadings and substantially improving the quality of the Connecticut River was significantly influenced by the 1972 CWA. Subsequent to the enactment of this legislation, 125 new or upgraded treatment plants were constructed along the Connecticut River at a cost of nearly \$900 million (Conniff, 1990). From 1972 through 1984 eligible projects were funded 75 percent by federal grants, 15 percent by state grants, and 10 percent by local financing; prior to 1972 the federal share was 55 percent (CTDEP, 1982). Three secondary wastewater treatment plants in the Hartford area (Hartford, East Hartford, and Rocky Hill) were completed by the mid-1970s (Gilbert, 1991).

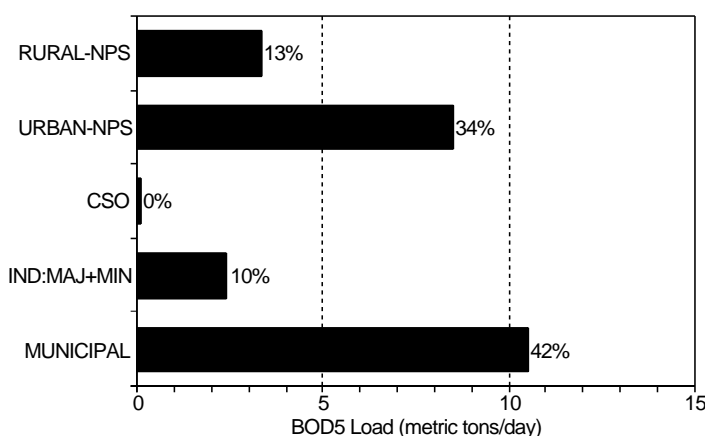
One of the major problems still facing this important New England waterway, however, is combined sewer overflows (CSOs). Overflows during storm events can still cause discharge of untreated sewage into the Connecticut River between Springfield, Massachusetts, and Middletown, Connecticut. CSO problems are the principal reason the Connecticut River does not consistently meet the Class B fishable/swimmable standard for fecal coliform in northern Connecticut (above Middletown) (Mauger, 1991).

## **Impact of Wastewater Treatment: Pollutant Loading and Water Quality Trends**

As a result of implementation of municipal and industrial wastewater treatment in the Connecticut River Basin, total pollutant loading has decreased substantially in the past 30 to 40 years. The approximate total population served by the 22 sewer systems in the Connecticut and Massachusetts portions of the river basin in 1963 was 734,265 people; of these, 282,590 (38 percent) resided in East Hartford and Hartford, Connecticut (Kittrell, 1963). In 1990 the sewered population of the greater Hartford metropolitan area was 366,574, served by the Hartford, East Hartford, and Rocky Hill facilities. The largest of these, the Hartford water pollution control plant, currently has secondary treatment with upgrades from 60 mgd to 80 mgd by 1993 (Gilbert, 1991).

Since implementation of the 1972 CWA, substantial reductions in point source loads of oxidizable materials have been achieved as a result of technology- and water quality-based effluent controls on municipal and industrial dischargers in the Connecticut River watershed. Nonpoint source runoff, driven by the land uses and hydrologic characteristics of the watershed, also contributes a pollutant load to the Connecticut River that must be considered in a complete evaluation of the impact of regulatory policy and controls on long-term water quality trends. To evaluate the relative significance of point and nonpoint source pollutant loads, inventories of NPDES point source dischargers, land uses, and land use-dependent export coefficients (Bondelid et al., 1999) have been used to estimate catalog unit-based point (municipal, industrial, CSOs) source and nonpoint (rural, urban<sup>1</sup>) source loads of BOD<sub>5</sub> for contemporary (ca. 1995) conditions in the case study area (Figure 5-6). Municipal facilities contribute 42 percent (10.5 metric tons/day) of the total estimated BOD<sub>5</sub> load, while industrial dischargers account for 10 percent (2.4 metric tons/day) of the total BOD<sub>5</sub> load. Nonpoint sources of BOD<sub>5</sub> account for a total of 47 percent, with rural runoff contributing 13 percent (3.3 metric tons/day) and urban land uses accounting for 34 percent (8.5 metric tons/day) of the total load (Figure 5-6).

Oxygen depletion and high BOD<sub>5</sub> levels historically have been documented downstream from the major wastewater discharges in the Massachusetts and Connecticut segments of the river. Prior to upgrading publicly owned treatment works (POTWs) in the southern Massachusetts sections of the river, water quality monitoring data near the Connecticut/Massachusetts border documented that DO concentrations in the river violated the Massachusetts state standard (5 mg/L for non-low-flow periods) 22 percent of the days recorded in the early 1970s (June-October) (Isaac, 1991). Minimum recorded DO levels reached nearly 0 mg/L in a 1966 survey and less than 2.0 mg/L in 1971 (NCWQ, 1975) in Massachusetts. After POTW upgrades, by 1974 violations had dropped to only 6 percent of the days of record with DO less than 5 mg/L (Isaac, 1991) (Figure 5-7).



**Figure 5-6**

Comparison of point and nonpoint source loads of BOD<sub>5</sub> (ca. 1995) for the Lower Connecticut River Basin.

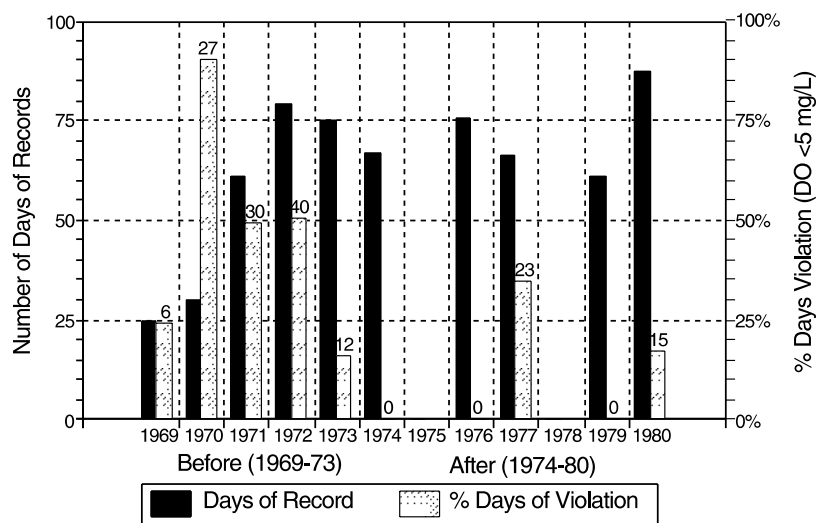
Source: Bondelid et al., 1999.

<sup>1</sup> For purposes of this comparison, urban stormwater runoff includes areas both outside (termed "nonpoint sources") and within (meeting the legal definition of a point source in section 502(14) of the CWA) the NPDES stormwater permit program.

**Figure 5-7**

Trends in violations of DO standard (DO < 5 mg/L) in summer (July-September) for the Connecticut River before (1969-1973) and after (1974-1980) construction and upgrade of municipal wastewater treatment facilities at Agwam, MA.

Source: Isaac, 1991.

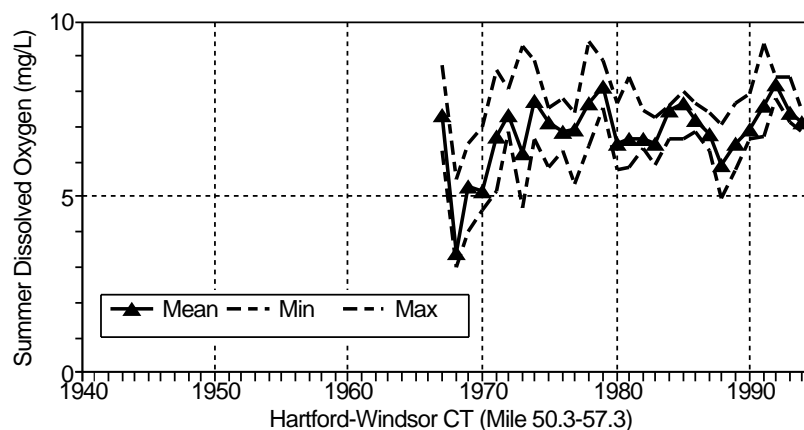


The average summer DO concentrations in the Lower Connecticut River in northern Connecticut (Hartford to Windsor) have also improved steadily since the mid-1960s (Figure 5-8). Corresponding to the increase in DO shown has been a progressive decline in ambient BOD<sub>5</sub> that reflects upgrades to Hartford area wastewater treatment facilities (Figure 5-9). Since the early 1970s, the average summer (July to September) DO levels in the Lower Connecticut River from Haddam to Middletown have remained above 7 mg/L (Figure 5-10). In a September 1988 intensive survey of water quality in the Lower Connecticut River, the DO concentrations ranged from 7.3 to 7.9 mg/L for all 10 stations sampled from the Massachusetts/Connecticut border to near the mouth of the river (CTDEP, 1988). The improvement in water quality in the Lower Connecticut River as a result of the significant reductions in oxidizable pollutant loading over the past 30 years has been substantial.

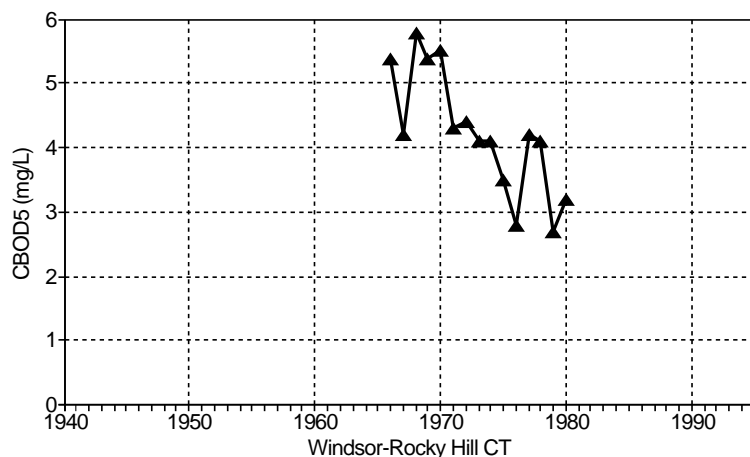
**Figure 5-8**

Long-term trends in DO for the Lower Connecticut River from Hartford to Windsor, CT (RF1-01080205029, miles 50.3-57.3).

Source: USEPA (STORET).

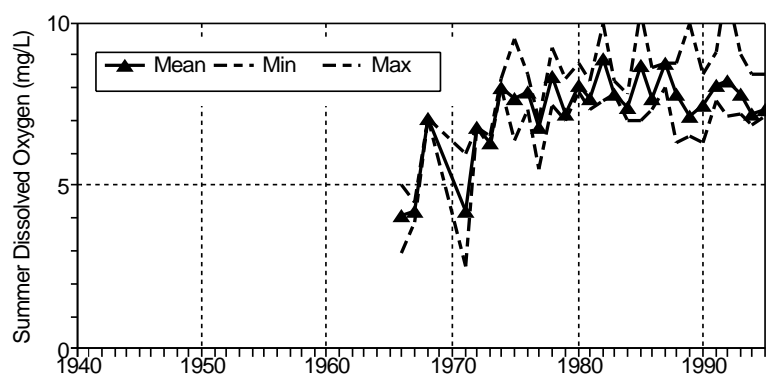




**Figure 5-9**

Long-term trends in BOD<sub>5</sub> in the Lower Connecticut River from Windsor to Rocky Hill, CT.

Source: Reimold, 1991.

**Figure 5-10**

Long-term trends in DO for the Lower Connecticut River from Haddam to Middletown, CT. (RF1-01080205021, miles 16.3-21.6).

Source: USEPA (STORET).

## Impacts of Wastewater Treatment: Recreation and Living Resources Trends

Information on biotic populations in the Connecticut River is scarce for most of the period previous to 1975 (Center for the Environment and Man, Inc., 1975). The precolonial salmon population was very large and supplied Native Americans and, later, early colonists with an abundant food supply. A long absence of Atlantic salmon in the river was noted between 1874 and the late 1970s. An Atlantic salmon caught in 1977 was the first documented occurrence of the fish in the river since 1874 (USEPA, 1980).

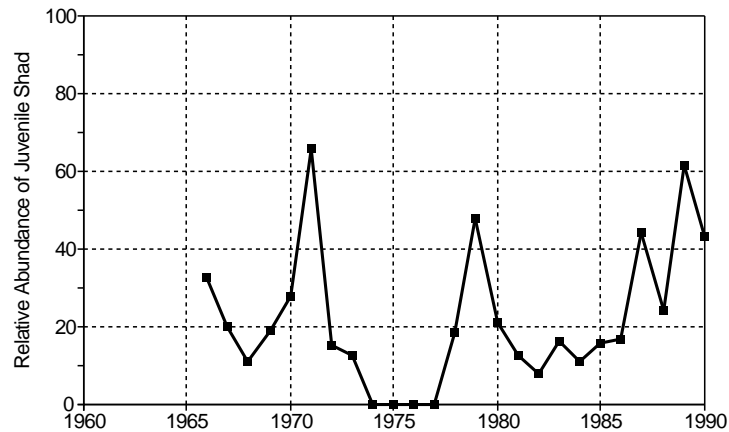
The absence of salmon can be attributed partially to dam construction, which prevented the fish from migrating upstream to spawn, and partially to water pollution. The first dam across the river was constructed in 1798 at Turners Falls, Massachusetts (Jobin, 1998). Fish ladders were built around dams when people began to understand that the dams prevented migration, yet 200,000 hatchery salmon placed in the river between 1968 and the early 1970s failed to return to the river to spawn, presumably because of the poor water quality (USEPA, 1980). Efforts to clean up the river began after passage of the 1972 CWA, and the return of the salmon in the late 1970s can be attributed to improved water quality.

Another anadromous fish species historically important to commercial and recreational fishing on the Connecticut River is the American shad. Shad had a precarious existence in the river before 1975 (Center for Environment and Man,

**Figure 5-11**

Long-term trends of shad relative abundance for the Lower Connecticut River.

Source: Savoy and Shake, 1991.



Inc., 1975), but their population increased afterward (Figure 5-11). The estimated mean population for the years 1975-1989 was 841,265 (Savoy, 1991). The 1990 estimated population was 654,885, lower than the previous 14-year mean but considered by the Connecticut Department of Environmental Protection (CTDEP) to be stable.

Other indices lead to the conclusion that the shad population is faring well in the Connecticut River. The 1990 commercial catch of shad in the river ( $x = 9687$ , adjusted for angler effort) was nearly twice the 1989 catch ( $x = 5243$ ) and reversed a general declining trend that lasted from 1986 to 1989 (Savoy, 1991). Similarly, juvenile shad had strong relative abundances from 1987 to 1990 (Figure 5-11), indicating good reproductive success (Savoy, 1991). Juvenile fish are generally less tolerant than adults of low DO concentrations, so an improvement in reproductive success is a good indicator of improving water quality.

## Summary and Conclusions

The federal, state, and local funding for construction of municipal wastewater treatment facilities in the Connecticut River Basin has led to significant improvement in water quality since the 1960s. A river basin that during the early 1970s was considered a flowing sewer is now a popular recreational area. One measure of the improvement in the fishable/swimmable quality of the river is documented by the U.S. Fish and Wildlife Service. Dramatic improvements in water quality, along with the installation of fish ladders to eliminate physical barriers to migration, have resulted in the successful return of Atlantic salmon to the Connecticut River.

Concentrations of total nitrogen and total phosphorus in the Connecticut River case study area since the CWA have followed the national trends—phosphorus and ammonia-N have decreased with associated increases in nitrate-N and total-nitrogen, indicating that improved wastewater treatment has improved water quality (Garabedian et al., 1998). In its report *Water Quality in the Connecticut, Housatonic, and Thames River Basins, Connecticut, Massachusetts, New Hampshire, New York, and Vermont, 1992-95*, the U.S. Geological Survey concluded that increasing nitrate concentrations may contribute to eutrophication in Long Island Sound.

## References

- Bondelid, T., C. Griffiths, and G. Van Houten. 1999. *A national water pollution control assessment model*. Draft technical report prepared for U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC, by Research Triangle Institute, Durham, NC.
- Center for Environment and Man. 1975. *Environmental impact assessment. Water quality analysis*. Connecticut River. Prepared for the National Commission on Water Quality, Washington, DC. Report No. NCWQ 75/51. National Technical Information Service No. PB-250 924. April.
- Conniff, R. 1990. The transformation of a river from sewer to suburbs in 20 years. *Smithsonian* 21(1):71-84.
- CSDC. 1991. *1990 Census population by municipality*. State of Connecticut Office of Policy and Management, Connecticut State Data Center, Hartford, CT.
- CTDEP. 1982. *The Connecticut River—worth the cost!* Connecticut Department of Environmental Protection, Water Compliance Division.
- CTDEP. 1988. *Connecticut River intensive survey, September 7-8, 1988*. Connecticut Department of Environmental Protection, Water Compliance Division.
- Forstall, R.L. 1995. Population by counties by decennial census: 1900 to 1990. U.S. Bureau of the Census, Population Division, Washington, DC. <<http://www.census.gov/population/www/censusdata/cencounts.html>>.
- Garabedian, S.P., J.F. Coles, S.J. Grady, E.C.T. Trench, and M.J. Zimmerman. 1998. *Water quality in the Connecticut, Housatonic, and Thames River Basins, Connecticut, Massachusetts, New Hampshire, New York, and Vermont, 1992-1995*. U.S. Geological Survey Circular 1155. U.S. Geological Survey, Reston, VA.
- Gilbert, P. 1991. Metropolitan District Commission, Hartford, CT. Personal communication.
- Isaac, R.A. 1991. POTW improvements raise water quality. *Water Environment and Technology* 3(6):69-72.
- Jobin, W.R. 1998. *Sustainable management for dams and waters*. CRC Press, Boca Raton, FL.
- Kittrell, F.W. 1963. *Report to the conference in the matter of pollution of the interstate waters of the Connecticut River, Massachusetts-Connecticut*. U.S. Department of Health, Education and Welfare. December.
- Mauger, A. 1991. Water Compliance Division, State of Connecticut Department of Environmental Protection, Hartford, CT. Personal communication.
- NCWQ. 1975. *Environmental impact assessment, water quality analysis - Connecticut River*. National Commission on Water Quality, Washington, DC.
- OMB. 1999. OMB Bulletin No. 99-04. Revised statistical definitions of Metropolitan Areas (MAs) and Guidance on uses of MA definitions. U.S. Census Bureau, Office of Management and Budget, Washington, DC. <<http://www.census.gov/population/www/estimates/metrodef.html>>.

- Reimold, R. 1991. Metcalf & Eddy, Inc., Boston, MA. Personal communication.
- Savoy, T. 1991. *Sturgeon status in Connecticut waters. Completion Report.* Project No. AFC-18. State of Connecticut, Department of Environmental Protection, Division of Marine Fisheries, Waterford, CT. June.
- Savoy, T., and D. Shake. 1991. *Population dynamics studies of American shad, Aloosa sapidissima in the Connecticut River.* U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. June 30.
- USACE. 1981. *Water resources development in Connecticut 1981.* U.S. Army Corps of Engineers, New England Division, Waltham, MA.
- USDOC. 1998. *Census of Population and Housing.* Prepared by U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census - Population Division, Washington, DC.
- USEPA. 1980. *National accomplishments in pollution control: 1970-1980. Some case histories. The Connecticut River: salmon are caught again.* U.S. Environmental Protection Agency, Office of Planning and Evaluation, Program Evaluation Division. December.
- USEPA (STORET). STOrage and RETrieval Water Quality Information System. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC.
- USGS. 1989. *Water resources data, Connecticut water year 1988.* USGS Water-Data Report CT-88-1. U.S. Geological Survey, Hartford, CT.
- USGS. 1999. Streamflow data downloaded from the U.S. Geological Survey's National Water Information System (NWIS)-W. Data retrieval for historical streamflow daily values. <<http://waterdata.usgs.gov/nwis-w>>.